

UK Patent Application (19) GB (11) 2 290 196 (13) A

(43) Date of A Publication 13.12.1995

(21) Application No 9411773.6

(22) Date of Filing 11.06.1994

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(51) INT CL⁶
H04B 7/26, H04Q 7/28

(52) UK CL (Edition N)
H4L LDM

(56) Documents Cited
GB 2075799 A WO 86/04199 A1

(58) Field of Search
UK CL (Edition M) H4K KY4T, H4L LDLX LECTE
LECTS LERA
INT CL⁵ H04B 7/204 7/212 7/24 7/26, H04Q 7/04

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(54) Reducing access time in trunking radio systems

(57) A calling unit verifies that a target unit is available by using the control channel and not the voice channel. The calling unit transmits (over the control channel) a paging command including the ID of a target unit selected from an ID list of a talk group. The target unit receives the paging command via a central unit, compares the ID therein with its own ID, transmits (over the control channel) an acknowledge signal to the calling unit via the central unit, and transmits (over the control channel) a group call request signal to the central unit in response to operation of its PTT switch. The central unit then transmits a group call channel grant command over the control channel, in response to which the calling unit switches to receive on an assigned voice channel and the target unit switches to transmit on an assigned voice channel. The target unit generates a page alert signal such as a bleep, ringing tone or flashing LED. If the target unit PTT switch is not then operated within a preset time, the alert signal is stopped but a visual signal continues to be given to indicate that someone has called.

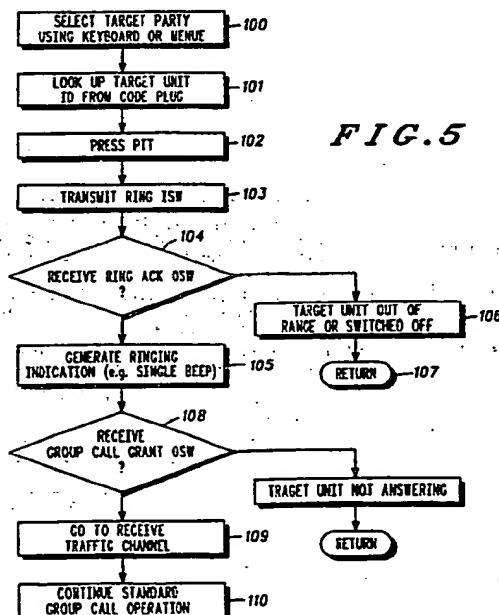


FIG. 5

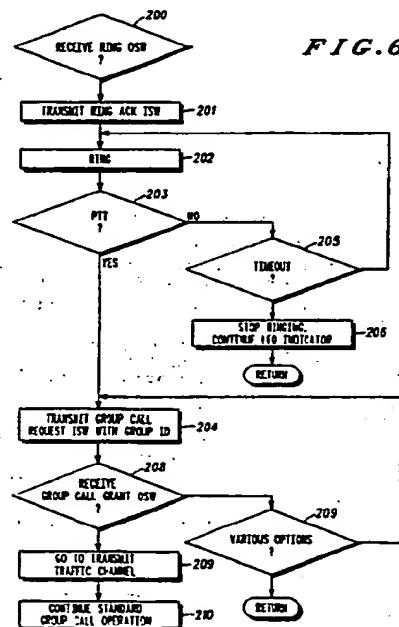
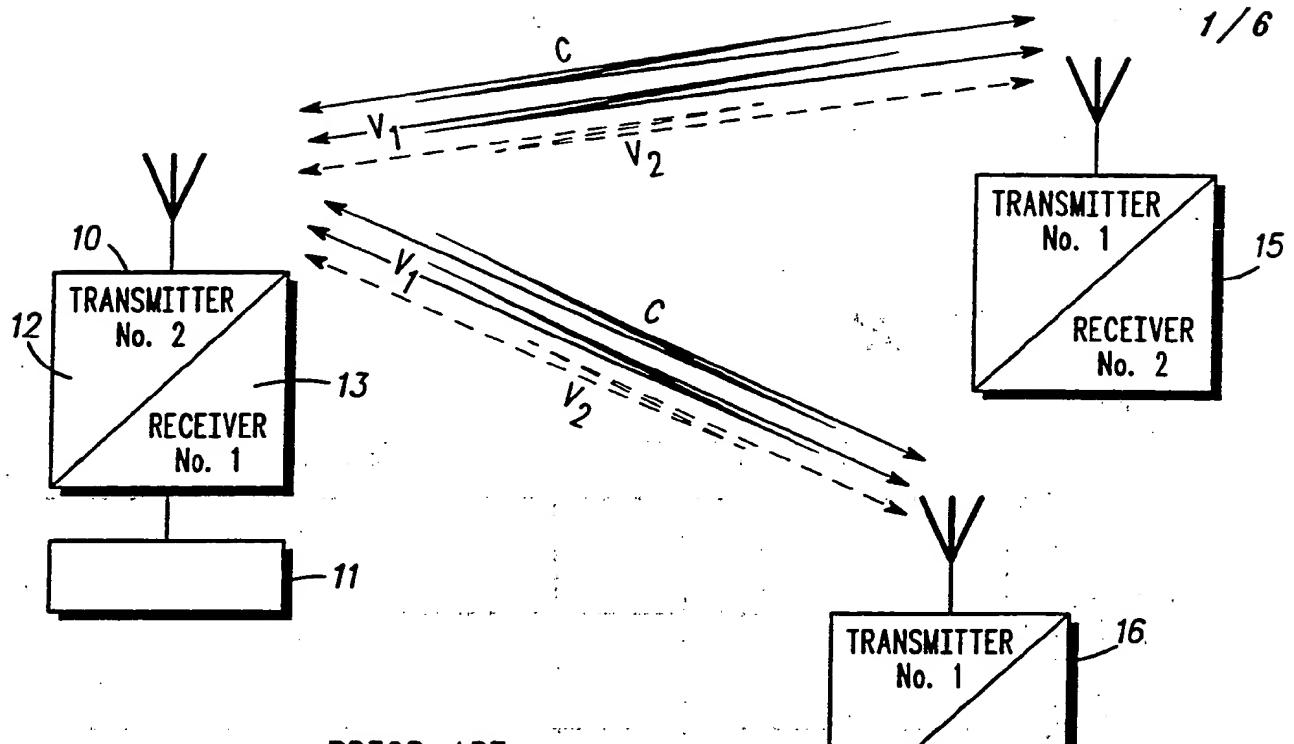


FIG. 6



-PRIOR ART-

FIG. 1

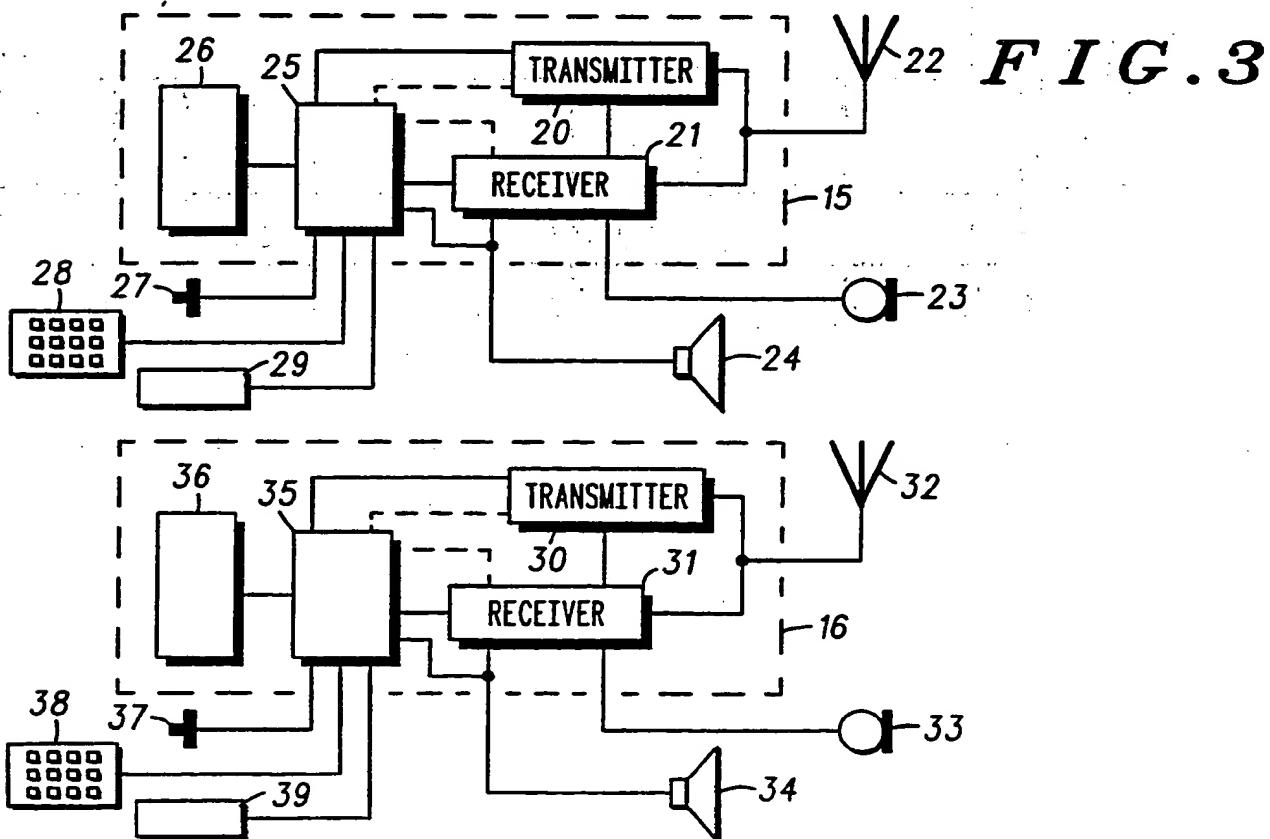


FIG. 2

-PRIOR ART-

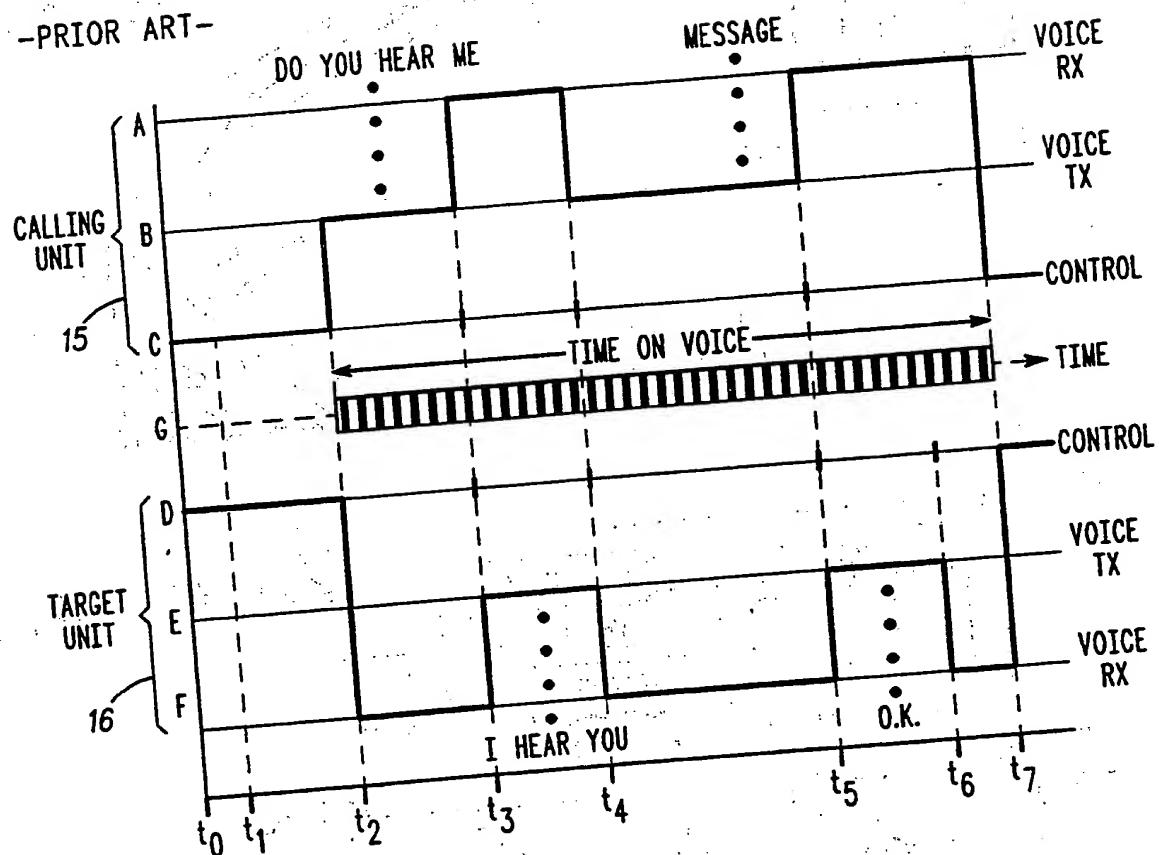
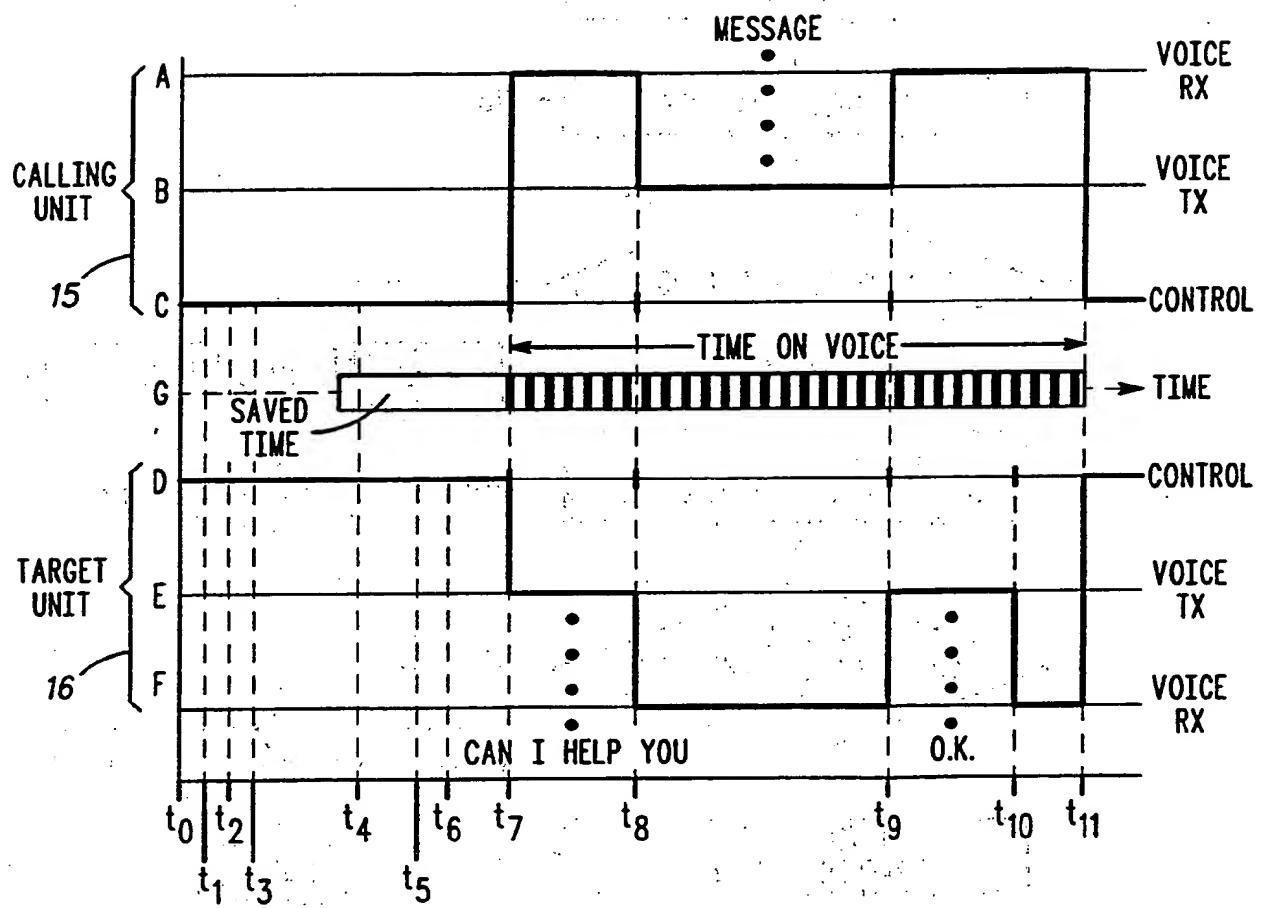


FIG. 4



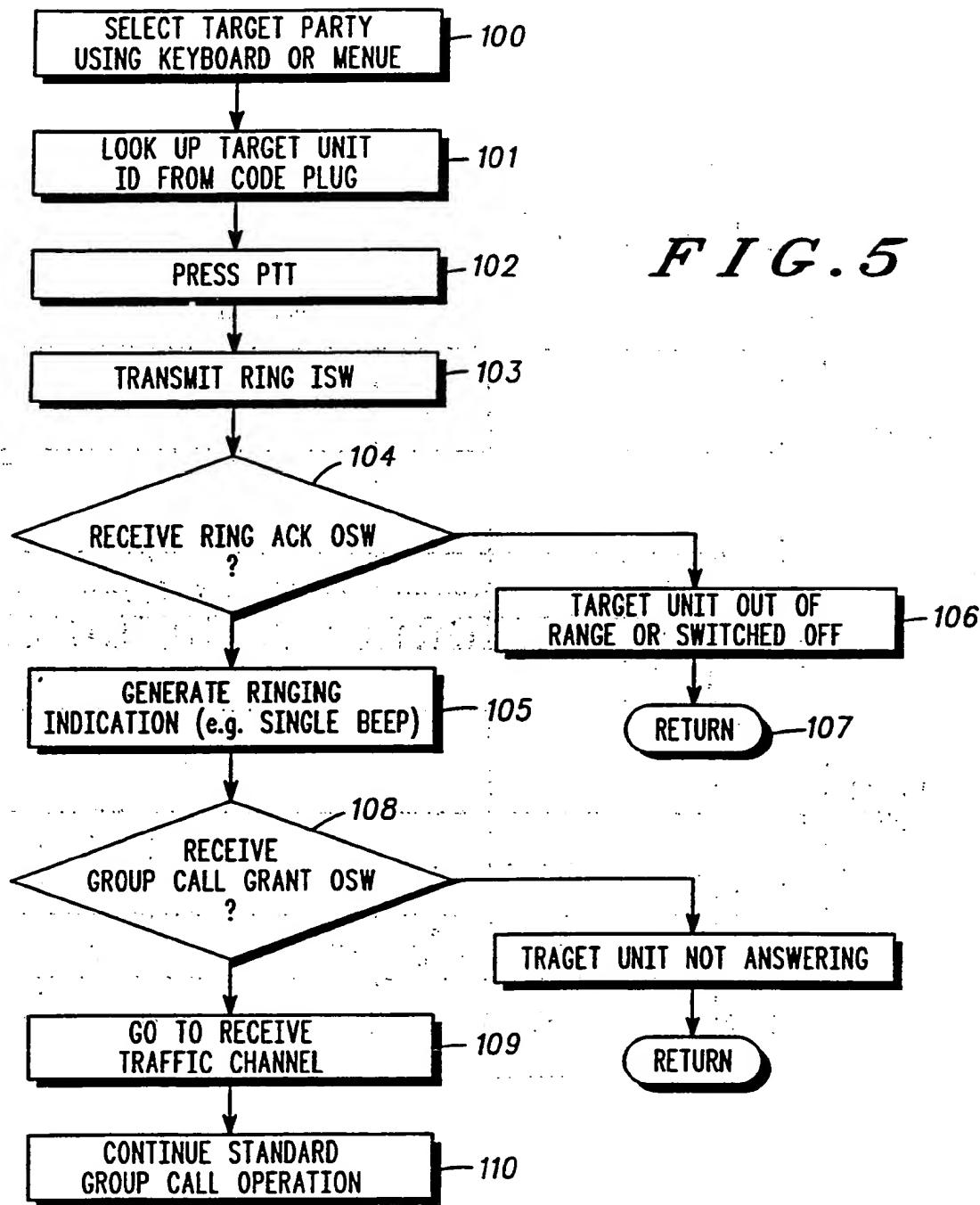
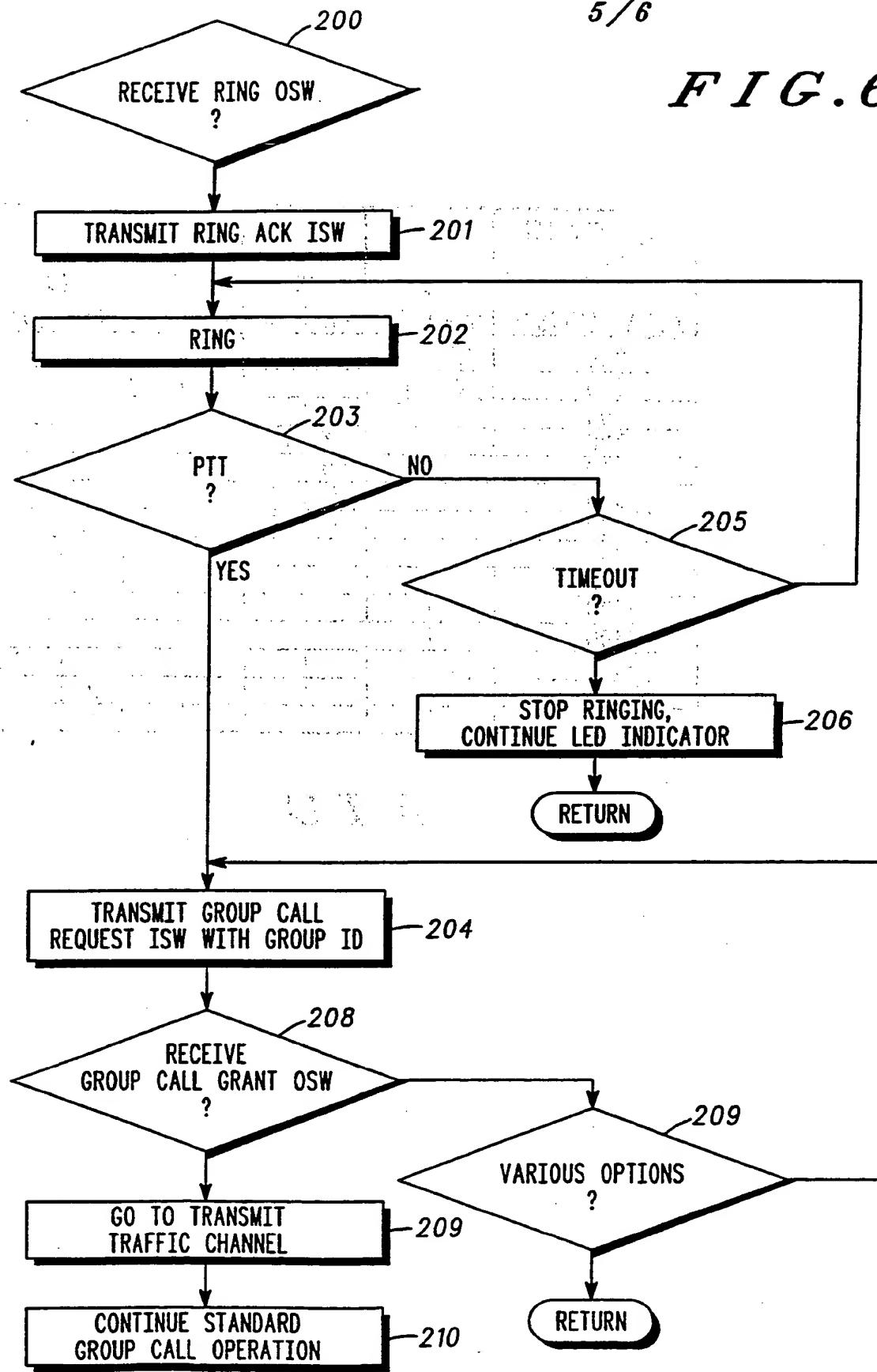


FIG. 6



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ACTIVE UNITS	CHANNELS		5		10		15		20	
	NOW	EDC	NOW	EDC	NOW	EDC	NOW	EDC	NOW	EDC
200	0.5	0.3								
300	2	1.4								
400	9	6								
700			0.5	0.3						
800			1.5	1						
900			3	2						
1000			10	7						
1200					0.5	0.3				
1400					2	1.4				
1500					4	3				
1600					10	7				
1900							1	0.7		
2000							2	1.4		
2100							4	3		

FIG.7

TRUNKING RADIO SYSTEM AND METHOD OF OPERATION AND
RADIO UNIT WITH ENHANCED DISPATCH CALLINGField of the Invention

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This invention relates to trunking radio systems, that is to say two-way radio systems having a central unit for transmitting channel grant commands over a control channel (frequency divided, time divided or divided by other possible access techniques) and other radio units (e.g. mobile radios) operating under the control of the central unit. The invention relates to dispatch calling on such a system, that is to say one to one or one to many calling from a fixed central unit to a radio or between radios. Separately and in addition, the invention relates to a method of operation of a trunking radio system and a radio unit *per se*.

15

Background to the Invention

Trunked radio systems are typically used to share dynamically a number of channels, e.g. (radio frequency RF) channels, amongst many radios engaged in a group or unit to unit or for telephone interconnect calls. Instead of sharing RF channels, trunked radio systems can share time divided channels or code divided channels.

Trunking allows the communication needs of a large number of users to be efficiently met by sharing a small number of trunks (communication paths).

Trunking is the automatic and dynamic allocation of a small number of radio channels among many users. The effectiveness of trunking is based on the following factors: (a) the percentage of time that any individual user requires a channel is very small and (b) the probability that many users will require a channel at the same instance is exceedingly small.

The most obvious benefit of a trunked radio system is its increased efficiency, i.e. the ability to reduce radio user waiting times (busy times).

Although busy periods are of short duration, trunking systems must be designed to accommodate peak hour message traffic. System performance characteristics are therefore stated in relation to busy hour (worst case) periods.

There is no simple rule in determining loading requirements. There are trade offs between system loading, number of channels and estimated access times. Variables which influence system performance include: (a)

how users use their system; (b) the number of talk groups on the system (c) the type of users; (d) use of individual calling capabilities.

For example, simulations show that with 200 active units and five channels available, an average busy hour waiting time is 0.5 seconds, 5 increasing to 9 seconds when there are 400 active units.

The reason for long wait times is saturation of the traffic (e.g. voice) channels. A party pressing the push-to-talk (PTT) button sends a call request inbound signalling word (ISW) to a central unit and must wait for the central unit to allocate a voice channel which is achieved by the central 10 unit transmitting a call grant outbound signalling word (OSW) on the control channel indicating which voice channel is to be used. The call grant OSW is transmitted only when the central unit determines that there is a free voice channel.

There is a need for easing congestion in a trunking radio system and 15 improving channel access times.

Summary of the Invention

According to one aspect of the present invention, a trunking radio 20 system is provided comprising first and second radio units and a central unit. The first unit comprises a memory with a list of identification numbers (IDs) for members of a talk group of which the first unit is a member, selection means for selecting an ID from the memory, a transmitter for transmitting a paging command with the selected ID over a control channel, 25 a receiver for receiving a channel grant command and channel selection means for selecting a traffic channel for further communication in response to receipt of the channel grant command. The second unit comprises: a receiver for receiving a paging command with an ID over the control channel, for receiving a group call channel grant command over the control channel and for receiving traffic over a traffic channel; means for comparing the ID with a predetermined ID for the second unit and determining that the 30 unit is being paged; alert means for generating an alert signal in response to the paging command; means for inputting a push-to-talk (PTT) (or equivalent) command; means for transmitting a group call request over the control channel upon inputting of a PTT command; and channel selection means for selecting a traffic channel for further communication upon receipt of a group call channel grant command. The central unit comprises means for repeating paging commands over the control channel and traffic over the traffic channel and for transmitting group call channel grant commands over 35

the control channel in response to receipt of group call requests when a traffic channel is available for group call.

According to another aspect of the invention, a radio unit for operation on a trunking radio system is provided comprising a receiver for receiving a paging command with an ID over a control channel, for receiving a group call channel grant command over the control channel and for receiving traffic over a traffic channel. The radio unit additionally has: means for comparing the ID with a predetermined ID and determining that the unit is being paged; alert means for generating an alert signal in response to the paging command; means for inputting a push-to-talk (PTT) command; means for transmitting a group call request over the control channel upon inputting of a PTT command following the alert signal; and channel selection means for selecting a traffic channel for further communication upon receipt of a group call channel grant command.

In another aspect of the invention, a method of operation of a trunking radio system is provided as defined in the claims.

The invention has the advantage of using the control channel instead of a voice channel at the beginning of every talk group call, thereby reducing the extent of usage of the voice channels and reducing the waiting time of the users.

The invention arises from the realisation that, in practice, the first few seconds of a talk group conversation generally involved no more than the calling party asking the called party to confirm, by voice, that the call is acknowledged. This simple activity can effectively be carried out with signalling on the control channel instead of voice on the voice or traffic channel.

An average call length of 10 seconds can typically be reduced to an average call length of 7 seconds by eliminating the first part of the call. This provides a gain of 30 percent of the voice channel use time. In addition, calls with no answer will not take any time on the voice channel. These calls account for about 10 percent of total calls.

Brief Description of the Drawings

FIG. 1 shows a generalised trunked radio system with a central unit and first and second radio units.

FIG. 2 shows operation of the system of FIG. 1 in accordance with prior art techniques.

FIG. 3 shows details of the first and second radio units of FIG. 1.

FIG. 4 shows operation of the system of FIG.1 in accordance with the preferred embodiment of the invention.

FIG. 5 shows operation of the calling unit of FIG. 1 in accordance with the preferred embodiment of the invention and

5 FIG. 6 shows operation of the receiving unit "target unit" of FIG. 1 in accordance with the preferred embodiment of the invention.

FIG. 7 shows a table of channel access times for existing systems and for a system in accordance with the preferred embodiment of the invention

10 Detailed Description of the Preferred Embodiment

Before describing the preferred embodiment in detail, reference is made to FIG.1 which shows the central unit 10 having a trunking controller 11 and having transmit and receive circuitry 12 and 13 respectively. Also

15 shown is a first mobile radio unit 15 and a second mobile radio unit 16. The central unit 10 communicates with the units 15 and 16 over a control channel C and a number of voice channels V1, V2 etc. Each of these channels is, for example a frequency pair of an inbound frequency and an outbound frequency. As shown, central unit 10 receives on a frequency Rx1 and transmits on frequency Tx2. Mobile radio units 15 and 16 both receive on frequency Rx2 and transmit on frequency Tx1. It should be noted that a transmission by the central unit 10 can be received by both the mobile radio units 15 and 16, provided that they are in group call mode. When one of the mobile radio units 15 and 16 wishes to transmit to the other, the central 20 unit 10 acts as a repeater on the voice channels.

25 Instead of frequency divided voice channels, the voice channels and indeed the control channel can all be provided on a single frequency in time divided manner.

30 The operation of the system of FIG. 1. in accordance with the known techniques is illustrated in FIG. 2.

FIG. 2 shows, at the top, the operation of a calling unit (unit 15) and, at the bottom, the operation of a target unit 16. The lines A B and C are voice receive operation, voice transmit operation and control channel operation respectively of the calling unit 15. The lines D E and F are 35 operation on the control channel and voice transmit operation and voice receive operation respectively at the target unit 16. Lines A and E are of course, on the same frequency and lines B and F are on the same frequency. Lines C and D are the same control channel frequency. The plot shows the calling unit 15 switching from the control channel into voice transmit mode

on the transmit channel and into voice receive mode on the receive channel etc. and, in the case of the target unit, switching from the control channel to the voice receive channel to the voice transmit channel etc.

Line G shows actual voice activity on the voice channel pair.

5 Operation of the prior arts system is as follows. At time t0, the holding unit 15 presses its PTT and time t1 a group call request ISW is transmitted by calling units 15 on the control channel. The tracking controller 11 assigns a voice channel to the top group and sends back a group call grant OSW at time t2. All the units that belong to the talk group move from the control channel to the voice channel and the call is started. At this time the initiator of the call does not know whether the target unit is 10 available and generally verifies this by asking "Do you hear me?". Assuming that the target unit is available, the operator presses his PTT at time t3 and replies "I hear you". Now the calling unit knows that the target unit is 15 available and can press his PTT at time T4 and deliver the message. Generally the target unit at time t5 presses his PTT and replies "OK". The target unit releases his PTT at time t6, and, after a hang time on the voice channel, both units (and any other members of the talk group) move back to the control channel at time t7. The total time of usage of the voice channel 20 is shown from time t2 to time t7.

The preferred embodiment is now described in detail, by way of example only.

Referring to FIG. 3 the calling unit 15 and the target unit 16 have 25 identical construction. The calling unit 15 has a transmitter 20 and a receiver 21 coupled to antenna 22. The transmitter 20 receives a voice from a microphone 23. The receiver 21 delivers voice through a loudspeaker 24. A microprocessor 25 delivers signalling to the transmitter 20 for transmission and receives signalling from the receiver 21 for control. The microprocessor 25 additionally controls both the transceiver 20 and the 30 receiver 21 e.g. controlling channel frequency selection. A code plug memory 26 is provided, connected to the microprocessor 25. A PTT button 27 and a keypad or other input device 28 are provided. A display 29 is provided for use in conjunction with the keypad 28. The elements 20 to 29 of unit 15 are present in unit 16 and are correspondingly numbered as elements 30 to 39.

35 Operation will be described with reference to FIG. 4, which is set out in FIG. 2 with lines A, B, C through to G representing the same operations as corresponding lines in FIG. 2. The following signalling commands are used. These signalling commands are known from existing trunking

systems where they are used for selective calling (i.e. individual one-to-one calling) or for telephone interconnect.

PAGE ISW

5 This is a signal that a unit sends to the central site controller on the control channel, asking to send a page to the target unit.

PAGE OSW

10 This is a signal that the central site controller sends to a unit, on the control channel, passing the page request to the target unit. The signal is sent in response to a PAGE ISW.

PAGE ACK ISW

15 This is a signal that a target unit sends to the central site controller on the control channel, verifying the reception of the PAGE OSW.

PAGE ACK OSW

20 This is a signal that the central site controller sends to the unit, on the control channel, passing the reception of the PAGE OSW by the target unit to the initiating unit. The signal is sent in response to a PAGE ACK ISW.

25 To initiate a call, the user of target unit 15 enters an identification number for the target unit 16. This is achieved by the calling unit 15 storing in its code plug memory 26 the ID's of all the other units in a given talk group. These ID's may be accompanied by alphabetical information and the user may scroll through a list of names to select the target unit, using the keypad 28 and the display (29). Having selected the target unit ID, he presses his PTT at time t_0 and at time t_1 a page message (or PAGE ISW) is sent on the control channel. The initiating unit waits for the target unit to request a voice channel assignment. This is achieved as follows. The target unit receives the PAGE OSW repeated by the central unit 10 at time t_2 . At time t_3 the target unit sends a PAGE ACK ISW. This is repeated by the central unit 10 at time t_4 , so that the calling unit 15 is able to be given an audible or visual indication that ringing is taking place at the target unit.

30 Assuming that the target unit is able and willing to answer, the user presses his PTT at time t_5 and at time t_6 he transmits a group call request ISW on the control channel. At time t_7 the central unit 10 transmits a group called grant OSW and both units 15 and 16 move to the voice channel pair (unit 15

for reception and unit 16 for transmission). Between times t7 and t8 the target user can transmit voice to ask the reason for the call and thereafter operation is as described before with the calling unit pressing its PTT at time t8, the target unit completing the conversation between times t9 and 5 t10 and the hang up time expiring at time t11. In this manner, the initiator unit verifies that the target unit is available by using the control channel and not the voice channel. The time on the voice channel is between times t7 and t11 (shown at G) and the time saved on the voice channel is between times t4 and t7. Note that this time is also saved if the target unit is not 10 available and does not press its PTT at time t7. In such a case, no transmission at all takes place on the voice channel.

A particularly preferred feature is that, in the event of the target unit failing to respond, an indication (for example a visual indication) is given that someone called, so that the target user can reply when possible.

15 Referring to FIG. 5, the operation of the microprocessor 25 at the calling unit 15 is described in greater detail. In step 100, the user selects the target party using the keyboard 28 or a menu. The microprocessor in step 101 looks up the target unit ID from the code plug 26. The user presses the PTT 27 in step 102 (time t0 in FIG. 4). The microprocessor 25 supplies a 20 PAGE ISW to the transmitter 20 in step 103 and this is transmitted. If the receiver 21 receives a PAGE ACK OSW, this is provided to the microprocessor 25 in step 104 and the process proceeds to step 105. In the absence of a PAGE ACK OSW, the microprocessor 25 can conclude that the target unit is out of range or is switched off (step 106) and the process 25 returns to a starting point or idle state (step 107). Following step 105, if a group call grant OSW is received in step 108, the microprocessor 25 causes the receiver 21 to tune to the receive voice channel (step 109) and group call operation continues as is well known in the art (step 110).

30 In the target unit 16, the operation is as shown in FIG. 6. If the receiver 31 receives a PAGE OSW, this is passed to the microprocessor 35 (step 200) and in step 201 a PAGE ACK ISW is transmitted by transmitter 30. Simultaneously (step 202) a page alert is generated. This can take the form of a loud bleep or a flashing LED or a telephone ringing-tone. This is generated by microprocessor 35 and fed through loudspeaker 34. A 35 telephone ringing tone is a less preferred form of tone, as it is preferable that the target unit user is not led to believe that a telephone interconnect call is received. This is because he must be aware that continued operation will be of a group call nature. If, following step 202, the target unit user presses the PTT 37 (step 203) the process continues to step 204. Otherwise, after a time-

out (205) the ringing or other alert is stopped in step 206 and the program returns to the initial state. Note that in step 206, a visual indicator continues to be given in the form of an LED or other indication on display 39.

5 Following from step 204, if a receive group call grant OSW is received (step 208) the program continues to step 209, where the microprocessor 35 causes the transmitter 30 to tune to the transmit traffic channel and operation continues in step 210 as standard group call operation well known to those skilled in the art. If, in step 208, there is no group call grant OSW 10 received, various options are possible in step 209, including re-transmitting the group call request ISW with the group ID, or other similar options, finally resulting in return to the initial state if no group call grant OSW is received.

Note that in step 204 there are a number of options for identifying the 15 group to which the group call request relates. When the target units sends its group call request ISW, this ISW includes an opcode which is visibly a group call request opcode (as opposed to a selected call request off opcode). Depending on the type of system, the group can be identified in the group 20 call request or at the central unit. In a system having affiliations stored in the trunking controller 11, the target unit sends its individual ID, call from the code plug 36 and the trunking controller 11 affiliates that ID with a talk group and transmits a group called grant OSW identifying that talk group.

In systems where there is no affiliation stored at the trunking controller 11, a dual ISW can be sent with (a) individual ID and (b) a talk 25 group ID. A talk group ID is transmitted by the central unit 10 in the group call grant OSW. All units of the talk group identify their own talk group ID and on receipt of a talk group ID any units of that talk group tune to the receive voice channel identified in the group called grant OSW.

Note that a unit 15 or 16 can respond to either its own individual ID 30 (for paging and for selective calling) or its talk group ID.

The arrangement differs from selective calling *inter alia* in that the group channel grant OSW is transmitted rather than a channel grant OSW identifying the individual units participating in the call.

Experience shows that a high percentage of group call transmissions 35 are in fact made for the benefit of individual units. The arrangement has the advantage that, in cases where the sending unit requires individual acknowledgement from a member of the group, time is saved on the voice channel in which that individual in the group would otherwise have to be

identified by voice and additionally time is saved in the event that that individual does not respond.

The invention also has the advantages of talk group communication. Talking to a group of units takes no more time on the voice channel than 5 talking to an individual unit. Group calling remains an efficient and popular mode of communication.

Referring to FIG. 7 a comparison is given between channel access times for an existing system and for a system in accordance with the preferred embodiment of the invention. The times for the existing system 10 are shown under the column heading "now", and in the case of the preferred embodiment of the invention, under the heading "EDC" (being an abbreviation for "Enhance Dispatch Calling" - an acronym devised for convenience to describe the invention).

FIG. 7 shows the number of active units on the system down the left 15 hand side of the table and the number of voice channels available across the top of the table. Thus, for example, for a system having 400 active units and 5 channels the average access time is reduced from 9 seconds to 6 seconds.

For a system having a 1000 units and 10 channels the average access time is reduced from 10 seconds to 7 seconds. These figures are simulations 20 and make certain assumptions regarding the behaviour of users on the system.

Claims

1. A trunking radio system comprising first and second radio units and a central unit, the central unit comprising:
 - 5 the first unit comprising:
 - a memory with a list of identification numbers (IDs) for members of a talk group of which the first unit is a member;
 - 10 selection means for selecting an ID from the memory;
 - a transmitter for transmitting a paging command with the selected ID over a control channel;
 - 15 a receiver for receiving a channel grant command and channel selection means for selecting a traffic channel for further communication in response to receipt of the channel grant command;
 - 20 the second unit comprising:
 - a receiver for receiving a paging command with an ID over the control channel; for receiving a group call channel grant command over the control channel and for receiving traffic over a traffic channel;
 - 25 means for comparing the ID with a predetermined ID for the second unit and determining that the unit is being paged;
 - means for generating an alert signal in response to the paging command;
 - 30 means for inputting a push-to-talk (PTT) command;
 - means for transmitting a group call request over the control channel upon inputting of a PTT command; and
 - channel selection means for selecting a traffic channel for further communication upon receipt of a group call channel grant command;
 - 35 and the central unit comprising means for repeating paging commands over the control channel and traffic over the traffic channel and for transmitting group call channel grant commands over the control channel in response to receipt of group call requests when a traffic channel is available for group call.
2. A trunking radio system according to claim 1, wherein the central unit comprises look-up means having affiliations between unit IDs and talkgroup IDs (TGIDs) and the means for transmitting group call channel

grant commands comprises means for receiving an ID of a radio unit, looking up the TGID of the talkgroup to which that radio unit is affiliated and transmitting a channel grant command including that TGID.

5 3. A trunking radio system according to claim 1, wherein each of the first and second units comprises storage means including the ID of the unit and a talkgroup ID (Tgid) of the unit and the means for transmitting the group call request comprises means for transmitting the ID and the TGID of the unit.

10 4. A trunking radio according to claim 1, wherein the alert means of the second unit comprises short-term alert means for providing a short-term alert and long-term indicator means for indicating to a user that a short term alert has occurred and a PTT command has not been input in response to the short term alert.

15 5. A method of operating a trunking radio system having first and second radio units and a central unit, the method comprising the steps of:
at the first unit:

20 selecting an identification number (ID) identifying the second unit;
transmitting a paging command with the selected ID over a control channel;
receiving a channel grant command and
selecting a traffic channel for further communication in
25 response to receipt of the channel grant command;

at the second unit:

30 receiving a paging command with an ID over the control channel;
comparing the ID with a predetermined ID for the second unit and determining that the unit is being paged;
generating an alert signal in response to the paging command;
user-selectively receiving at an input a push-to-talk (PTT) command;
35 transmitting a group call request over the control channel upon receipt of a PTT command;
receiving a group call channel grant command and
selecting a traffic channel for further communication upon receipt of a group call channel grant command;

and at the central unit:

repeating paging commands over the control channel and traffic over the traffic channel and transmitting group call channel grant commands over the control channel in response to receipt of group call requests when a traffic channel is available for group call.

5

6. A method according to claim 5, comprising the steps of, at the first unit, receiving an ID of a radio unit, looking up a talkgroup identification number (TGIN) of the talkgroup to which that radio unit is affiliated and transmitting a channel grant command including that TGIN.

10

7. A method according to claim 5, comprising the step of, at the second unit, transmitting with the group call request the ID of the second unit and 15 the talkgroup identification number (TGIN) of the first and second units.

20

8. A radio unit for operation on a trunking radio system comprising:

a receiver for receiving a paging command with an ID over a control channel, for receiving a group call channel grant command over the control channel and for receiving traffic over a traffic channel;

25 means for comparing the ID with a predetermined ID and determining that the unit is being paged;

30 alert means for generating an alert signal in response to the paging command;

means for inputting a push-to-talk (PTT) command;

35 means for transmitting a group call request over the control channel upon inputting of a PTT command following the alert signal; and

channel selection means for selecting a traffic channel for further communication upon receipt of a group call channel grant command.

35

9. A radio according to claim 8, wherein the alert means comprises short-term alert means for providing a short-term alert and long-term

indicator means for indicating to a user that a short term alert has occurred and a PTT command has not been input in response to the short term alert.

.miners report to the Comptroller under Section 17
(The Search report)

Relevant Technical Fields

(i) UK Cl (Ed.M) H4K KY4T H4L LDLX, LECTE, LECTS, LERA

(ii) Int Cl (Ed.5) H04B 7/204, 7/212, 7/24, 7/26 H04Q 7/04

Databases (see below)

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Search Examiner
M J BILLINGDate of completion of Search
16 AUGUST 1994Documents considered relevant
following a search in respect of
Claims :-
1-9

Categories of documents

X: Document indicating lack of novelty or of inventive step. P: Document published on or after the declared priority date but before the filing date of the present application.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category. E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

A: Document indicating technological background and/or state of the art. &: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2075799 A	(WESTERN ELECTRIC) eg. see page 3 line 56 page 4 line 29, page 5 line 67 to page 6 line 80	8 at least
A	WO 86/04199 A1	(MOTOROLA) eg. see page 7 line 38 to page 9 line 38	1, 5

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